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RESEARCH ARTICLE

DIAGNOSTIC IMAGING IN TEMPOROMANDIBULAR JOINT DISORDERS - A REVIEW

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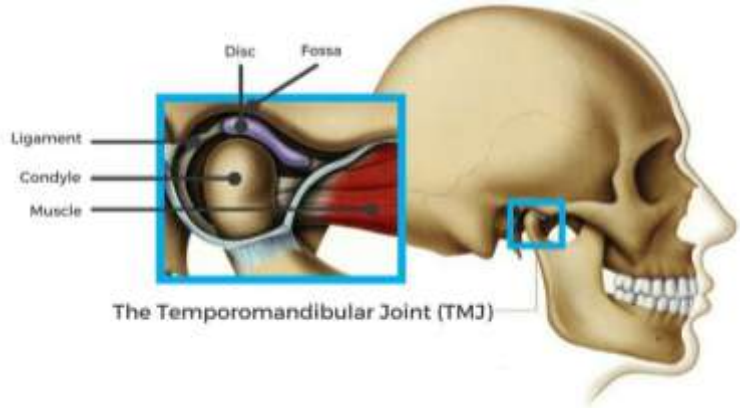
Abstract

Temporomandibular joint disorders (TMDs) are a group of disorders which are complex and multifactorial. The identification of the major etiologic factors are essential for the success of any therapeutical procedures. Diagnosis of TMDs are mainly based on thorough clinical examination along with the analysis of presenting signs and symptoms. Sometimes, other diagnostic tests are used inorder to gather more information or to confirm the clinical diagnosis. Various imaging modalities are used to identify the morphology of the joint as well as to study the functional relationship of the condyle to the fossa. This article aims at discussing briefly the various diagnostic imaging techniques of TMDs.

Introduction:-

Temporomandibular joint (TMJ) is a ginglymoarthrodial – synovial – compound joint which consists of an articular disc, 2 bones(mandible and temporal bone), a fibrous capsule, intra- articular fluid, a synovial membrane and ligaments[1]. (fig 1)



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Temporomandibular joint disorders (TMDs) is an area explored extensively but still remain mysterious over all these years. According to AAOP (American Academy Of Orofacial Pain), TMD is defined as a complex term covering a number of clinical problems involving the masticatory muscles, the joint and the associated structures. The most common clinical sign include pain, limited mouth opening and joint sounds (clicking, crepitation).[2]

Proper clinical examination is the most important step in the diagnosis of TMDs. The complex anatomy and location of the joint demands the need for various imaging techniques to aid in the diagnosis and treatment planning. It depends on the clinicians experience and expertise to decide on the type of imaging to be done in each clinical scenario.

Conventional radiographic TMJ projections like transpharyngeal, transcranial, panoramic radiograph, conventional tomographic sections of TMJ may be adequate in a number of clinical situations. But there are bony alterations that occur in these disorders like erosions, osteophytes, pneumatization of articular eminence that are difficult to be detected in conventional radiographs due to overlapping of the anatomic structures [3]. This warrants the use of advanced imaging modalities like, computed tomography, Magnetic Resonance Imaging (MRI), Cone Beam computed tomography (CBCT), Ultrasonography and Nuclide imaging.[4]

Conventional Radiographic Techniques[1]

1. Panoramic imaging
2. Lateral transcranial view
3. Transpharyngeal view
4. Transmaxillary (anteroposterior [AP]) view

Panoramic Imaging

It has been widely used in the dental clinics for the screening of condyles as its use results in minimum superimposition of structures over the condyles.[1] It helps in identifying any periodontal or odontogenic cause of orofacial pain.

It can be helpful in evaluating[5]

1) Late stages of degenerative bone changes
2) Condylar asymmetry
3) Hyperplasia, hypoplasia
4) Trauma
5) Tumours

Eventhough it has been used widely and is helpful in evaluating the bony structures it has got certain limitations such as[1]

1. Superimposition in cases of limited mouth opening
2. Articular fossae are usually obscured partially or totally
3. Being an infracranial view, the lateral pole is superimposed over the condylar head and hence the area representing the superior subarticular surface of the condyle is actually only the subarticular surface of the medial pole
4. Has a relatively low specificity and sensitivity when compared with CT[6,7]
5. Changes in head position could affect the image of TMJ, simulating different bone abnormalities.[8]

Panoramic radiography is useful in detecting bony changes of the condyle, but when these changes are suspected, and the radiography is normal, CT should be performed.[9]

Transcranial Projection

Imaging is done at different angulations in order to avoid the superposition of the temporal bone and the opposite TMJ.[10] Some studies consider the position of condyle in the fossa to be insignificant while certain studies consider the posterior positioning of condyle in the fossa as an indication of anterior disc displacement.[11,12,13] in this technique, the x-rays are directed inferiorly across the skull (above the midface) to the contralateral TMJ and recorded.[1]

It can be helpful in

1. Detecting advanced stages of degenerative changes in the joint.[10]
2. Assessing condylar position in relation to the fossa.[10]
3. But the limitations include
4. Wide variations in the condylar position even in asymptomatic patients[14,15]
5. Superimposes the medial pole of the condyle below the central subarticular surface and lateral pole[1]

Transpharyngeal View

Eventhough, this view is similar to the panoramic view, the direction of the x-rays (from below the angle of the mandible or through the sigmoid notch) make the angle at which condyles are projected not as great as in panoramic view.[1] It is more closer to a true lateral view. The condyles are demonstrated satisfactorily by this view, but the mandibular fossae is not visualized very well.

Transmaxillary View

It is obtained from anterior to posterior with the mouth wide open and the condyles translated out of the fossae.
It is helpful in obtaining

1. a good view of the superior subarticular bone of the condyle
2. a good view of the medial and lateral poles
3. an excellent view for evaluating a fracture in the neck of the condyle.

But its use is lost, if the condyles cannot be translated to the crest of eminence,as it results in the superimposition of subarticular bone.[1]

Advanced Imaging Techniques

1. Computed Tomography (CT)
2. Cone Beam Computed Tomography (CBCT)
3. Magnetic Resonance Imaging (MRI)
4. Ultrasonography (USG)
5. Nuclide Imaging

Computed Tomography (CT)

CT came into the field of TMJ evaluation in the 1980s.[16] CT is considered to be the best method to diagnose osseous changes in the TMJ. It allows multi planar reconstruction of TMJ structures, obtaining 3D imaging in open and closed mouth positions. [5]

CT can be used in evaluating
Degenerative changes in the joint[10]

1. surface erosions
2. osteophytes,
3. remodeling,
4. subcortical sclerosis,
5. articular surface flattening
6. Changes in the shape and location of the loading zone
7. Tumors, growth development anomalies and fractures

Basically, any CT examination of the TMJ should focus on the following: intactness of the cortex, normal size and shape of the condyles and their centered position in the fossa, the adequate joint spaces, centric relation loading zone.[5]
However, CT scans have some disadvantages such as[5]

1. The equipment is relatively expensive and therefore not always accessible.
2. CT scans expose the patient to more radiation than simpler films.
3. Visualization of the soft tissues of TMJ (disc, synovial membrane, ligaments, lateral pterygoid muscle) is not possible in CT.
4. Artefacts can appear due to the patient's accidental movement during examination (especially in children).

Cone Beam Computed Tomography (CBCT)

A CBCT machine uses a cone-shaped beam and a reciprocating solidstate flat panel detector, which rotates once around the patient (180-360 degrees) covering the defined anatomical volume (complete dental/ maxillofacial volume or limited regional area of interest) rather than slice-by-slice imaging found in conventional CT. Designation of this equipment is not based on the concept of sectional images but in computer processing of a single rotational scanning of the region of interest.[4]

Cone beam tomography can image both hard and soft tissues; therefore the disc-condyle relationship can be observed and evaluated without disturbing the existing anatomic relationships. Being introduced in TMJ evaluation in 1990s, cone beam CT is widely available now and provides high-resolution multiplanar reconstruction of the TMJ.[17,18]

The main advantage of cone beam CT, compared to CT, is the lower radiation dose to the patient.[19,20,21] The spatial resolution of cone beam CT is higher than that of conventional CT.[22] The reconstructed images are of high diagnostic quality, the examination time is shorter, and patient dose is lower than that with conventional CT. It may therefore be considered as the imaging technique of choice when investigation of bony changes of the TMJ is the task at hand.[4]

A review published by Silvia Caruso et al pointed out the main contributions of cone beam CT in the field of TMJ:[23]

1. allows the calculation of volume and surface of the condyle;
2. improves qualitative analyses of condylar surface and allows detecting the mandibular condyle shape;
3. improves the accuracy of linear measurements of mandibular condyle;
4. clarifies that, in case of facial asymmetry, the condyles are often symmetric, while joint space can change between the two sides;
5. clarifies the position of the condyle in the fossa.

Magnetic Resonance Imaging (MRI)

MRI has become the gold standard for evaluating the soft tissue of the TMJ, especially disc position. It uses a strong magnetic field to create changes in the energy level of the soft tissue molecules (principally hydrogen ions). These changes in energy levels create an image in a computer similar to a CT scan.[1] Imaging of soft tissues is superior to that of computed tomography, less invasive that arthrography, and more reliable than radiography.[4]

MRI could also detect the early signs of TMJ dysfunction, like thickening of anterior or posterior band, rupture of retrodiscal tissue, changes in shape of the disc, joint effusion.[24] Images can be obtained in all planes (sagittal, axial, coronal). In most scanning sequences, T1 weighted, T2 weighted and proton-density (PD) images are obtained. The PD images serve to visualize the disc-condyle relationship, while T2-weighted images are used in diagnosing inflammation in the joint.[25,26] T1-weighted sagittal images are the cornerstone of the TMJ examination; the anatomy is clearly depicted, and the imaging plane is optimal for assessing articular disk position. T2-weighted images are useful for detecting degenerative periarticular changes and the presence of a joint effusion.[27]

The slice thickness is important for image quality. The most frequent used section thickness is 3 mm. Reducing the slice thickness improves the quality of the images, but requires longer scanning time.[28]

In MRI examination, a pathological condition is considered to be present relative to the intermediate zone of the meniscus (as a point of reference) and its interposition between the condyle and the temporal bone.[29] Normal disc position, evaluated in the sagittal plane, is with the junction of posterior band aligned approximately at 12 o'clock, position relative to the condyle. Disc displacement is diagnosed when the posterior band sits in an anterior, posterior, medial or lateral position with regard to the condylar surface.[30] Synovitis can be clearly visualized on MRI images.[31]

The advantages of MRI are[22]

1. it is noninvasive
2. it requires no ionizing radiation for image acquisition
3. it permits a direct visualization of the disk and joint structures
4. multiplanar imaging is readily obtained and more easily interpretable

Among the disadvantages of the MRI investigation, the following can be mentioned[32,33,34]

1. it is costly and time consuming
2. restricted use in patients with claustrophobia or an inability to remain motionless
3. contradicted in patients who are pregnant, or who have pacemakers, intracranial vascular clips, or metal particles in vital structures
4. there is a possibility of missing the portion of condyle having a pseudo cyst
5. may miss different bone conditions and soft tissue calcifications with inflammatory diseases or tumors; in these cases, CT is the preferable imaging modality
6. it is normally a static image.

The clinician should note that the presence of a displaced disc in an MRI does not suggest a pathologic finding. It has been demonstrated that between 26% and 38% of normal, asymptomatic subjects reveal disc position abnormality on MRIs. These studies reveal that false positives and false negatives are common with these imaging techniques, and therefore care must be taken regarding their interruption.[1]

Ultrasonography (USG)

Nabeih et al in 1991 used High-resolution ultrasonography (USG) for the first time in TMJ exploration, using a 3.5 MHz transducer.[35] The principle upon which USG works is that ultrasonic sound waves emitted by the transducer propagate through the tissue against which they are aimed, and are partly reflected on transiting through dissimilar anatomical structures. The reflected sound waves are then read by the same emitting device, and translated into images.[36] It uses currently available types of ultrasonic equipment with a linear scanning transducer of 7.5–12 MHz frequency, which makes it possible to depict the narrow space of the jaw joint and the position of the joint disc and it reveals fluid or ligament adhesion.[37]

The variable levels of sensitivity and specificity reported in literature is due to the variation in the USG frequencies in different equipments. The use of high-resolution USG (transducer at least 7.5 MHz or higher) significantly increases the diagnostic value of this technique.[38,39]

USG can be helpful in detecting disc displacement and effusion to some extent. Normally, the disc is situated between two hyperechoic lines represented by the mandibular condyle and the articular eminence. If the disc is displaced in the closed-mouth position, the diagnosis is disc displacement. If the disc returns to its normal position during opening, the diagnosis is disc displacement with reduction. If not, the diagnosis is disc displacement without reduction.[5]

The advantages of USG are[4]

1. non-invasive
2. dynamic
3. inexpensive procedure
4. quick examination technique
5. available in most healthcare institutions.

The disadvantages include[4,5,40]

1. not recommended in diagnosis of degenerative changes of TMJ
2. difficulty in obtaining clear images due to overlying osseous structures
3. medial part of the disc cannot be visualized
4. diagnostic value solely depends on the clinician's skill and the equipment used
5. lack of standardization in conducting USG(selection and settings of transducer, mouth opening position, interpretation of results)

The use of higher resolution equipments in the future will help in improving the sensitivity, accuracy and positive predictive value of USG making it a reliable imaging modality.[41]

Nuclide Imaging

Nuclear medicine is the branch of medicine that deals with the use of radioactive substances in research, diagnosis and treatment. Radiopharmaceuticals are pharmaceuticals containing radioactive isotope as tracer and a ligand, i.e., a molecule, chemical compound or cell (e.g. granulocyte) that has an affinity towards a tissue or organ.[42]

Registration of radiation can be performed by means of a single static gamma camera (also known as a scintillation camera), one or more rotating gamma cameras or multi headed gamma cameras.

Depending on the type of registration device, the imaging methods are divided into
1. Scintigraphy,
2. Single-photon emission computed tomography (SPECT) and
3. Positron emission tomography (PET).

Scintigraphy

Scintigraphy helps in analysing the early changes in the TMJ. Osteotropic tracers are used in Bone scintigraphy, most commonly methylene diphosphonate (MDP) linked with radioactive technetium (99mTc), is injected into a vein (arm, hand or foot). MDP targets bone tissue, and its uptake depends on bone mineralisation, collagen content, vascularisation and bone remodelling. Forming of hydroxyapatite crystals in the areas of production of new osteoid tissue by osteoblasts leads to an increased uptake of tagged MDP; thus these areas accumulate more radioactive tracer and show up as "hot" .[43] Planar scintigraphy of TMJ is performed typically in anterior, posterior, right lateral and left lateral projections with a 500,000 count per each image.[44,45] Open-mouth bone scintigraphy was proved to be better than closed-mouth bone scan in patients with temporomandibular osteoarthritis as it is difficult to differentiate physiologic bone uptake in a condyle and glenoid fossa of temporal bone in closed-mouth position.[46]bone scintigraphy is not a routinely used technique but studies show that it is useful in diagnosing osteoarthritis of TMJ.

Single-Photon Emission Computed Tomography (SPECT)

SPECT is based on registration of emission of radiation by means of a rotating gamma camera to obtain projections from multiple angles. The acquired images are more precise regarding localisation of areas of tracer uptake when compared to scintigraphy eventhough the radiopharmaceuticals used are the same. The temporomandibular joint being quite a small joint situated close to the skull base and paranasal sinuses, is ideal for SPECT. [4]

The radionuclide examination sensitivity is high, its specificity is however low. Any inflammation, trauma or tumors increase the local isotope concentration. For this reason many studies state that radionuclide examination is relevant only as a screening method.[47]

The following applications of SPECT in TMJ imaging were reported[42]
1. Unilateral condylar hyperplasia
2. Bone tracer uptake in patients suffering from TMJ pain
3. Osteoarthritis
4. Quantitative evaluation of temporomandibular joint disorder (TMD)
5. Evaluation of the effects of functional orthopaedic treatment of TMJ.

Positron Emission Tomography

Positron Emission Tomography is a nuclear medicine imaging technique, which provides cross-sectional data based on the 3-dimensional localization of positrons emitted by radiotracers. The advantages of PET over scintigraphy are[4]
1. its cross-sectional nature
2. higher detection efficiency and spatial resolution
3. helpful in evaluating metabolic reactions in the body
4. provides functional information based on the interaction of the radiotracers at the molecular level.

Indications of PET in TMJ evaluation are[42]
1. early diagnostics of neoplasms;
2. staging of some tumours, e.g. lymphoma;
3. planning of radiotherapy; and
4. location of an unknown primary tumour with known metastases,
5. response to treatment,
6. follow-up and differentiation between recurrent tumour and post-treatment lesions induced by, e.g. radiotherapy

PET data reflects the distribution of the radiotracer in the area being imaged, but doesy not provide structural information relating to the anatomy of the patient.. In order to facilitate anatomic localization of areas of increased radiotracer uptake, PET is usually combined with computed tomography, which provides structural information of the patient.[48]

The first study to evaluate the clinical utility of PET/CT in patients with TMD was published in 2013 by Lee JW, et al.[44] They concluded that PET/CT showed high TMJ uptake rations in patients with osteoarthritis, while accuracy and sensitivity were higher than in conventional bone scintigraphy. Suh MS, et al investigated patients with temporomandibular joint disorder (TMD) by means of PET-CT with 8 F-sodium fluoride (NaF) as tracer and found out that this imaging modality was useful in arthralgia TMJ and TMD osteoarthritis and a correlation with the patients' response to splint therapy was ascertained.[45]

Conclusion:-

A proper case history and clinical examination along with appropriate imaging technique can help in the exact diagnosis and treatment planning in TMDs. Radiographic examination is helpful in initial diagnostic stages but the complex structure and function of TMJ makes it difficult in analysing the joint completely using radiographs. But it is still used and have stood the test of time. CT is considered one of the most reliable imaging technique of TMJs with its efficacy in detecting osseous changes. MRI is looked upon as the gold standard in diagnosing TMDs. It is the only exam that allows the identification of the disc, soft tissue, cortical bone contour and bone marrow of the mandibular condyle, featuring the complete form of joint disorders and displays with best advantage the soft tissue components of the TMJ as well as bone marrow abnormalities.[4]

CBCT has become more common nowadays. Its reduced radiation exposure compared to CT along with the three dimensional reconstruction has made it more dear to the clinicians. USG is a non-invasive and inexpensive technique that helps in detecting joint effusion and articular disorders. But the equipment used and the examiner's expertise greatly affects the interpretations in USG. Nuclear medicine and its use in the exploration of TMJ is a field of interest for the researchers as it can be useful in the diagnosis of most of the types of TMDs.

All these becomes helpful only with the thorough knowledge and understanding of the anatomy, physiology and biomechanics of TMJ.

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